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MEGALONOTUS SABULICOLA (HETEROPTERA: LYGAEIDAE), AN IMMIGRANT SEED PREDATOR OF *CENTAUREA* SPP. (ASTERACEAE): DISTRIBUTION AND HABITS IN EASTERN NORTH AMERICA

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Abstract.—The North American distribution of *Megalonotus sabulicola* (Thomson), a European rhyparochromine lygaeid accidentally introduced to the Pacific Northwest and East Coast, is reviewed. Delaware, New Jersey, Pennsylvania, Rhode Island, Virginia, and West Virginia are listed as new state records, and additional localities are cited for Maryland and New York. In the mid-Atlantic region this bug feeds mainly on fallen seeds of spotted knapweed, *Centaurea maculosa* Lam. (Asteraceae), a noxious weed of western rangelands and invasive plant in ruderal habitats of eastern North America. This bivoltine seed predator could be considered a beneficial immigrant because it destroys spotted knapweed seeds. Its effects on plant density, however, apparently are negligible. Characters are provided that facilitate recognition of this Palearctic bug in the New World fauna.

Key Words: immigrant insect, distribution, eastern North America, seed predation, spotted knapweed, *Centaurea maculosa*

Megalonotus sabulicola (Thomson) is a widespread Old World lygaeid known in Europe to range from Sweden and England south to the Mediterranean countries, where it seems particularly common, and east to the European U.S.S.R; it also occurs in northern Africa (Morocco) and in Turkey, Syria, and Israel (Slater 1964). In Europe, *M. sabulicola* was long considered a subspecies of *M. chiragra* (F.) and is so listed in Slater's (1964) world catalog. But, as Southwood (1963) pointed out, the two overlap in their range and sometimes even in habitat; therefore, *M. sabulicola* cannot be considered a subspecies of *M. chiragra*. Southwood (1963) and Roubal (1965) determined that these sympatric bugs do not substantially intergrade and concluded that they represent distinct species, although morphological separation is not always clearcut.

The habits of *M. sabulicola* in Europe are not well known. It has been collected from the litter layer in various microhabitats and apparently is most common in sandy areas (Butler 1923, Southwood and Leston 1959). Pfaler (1936) reported that adults overwinter and that Finnish populations are bivoltine. Several workers have provided ecological notes (Slater 1964 and references therein), but detailed information on host plants and biology is lacking for European populations.

The first New World record of this rhyparochromine was from California (as *Rhyparochromus chiragra californicus*) (Van Duzee 1928). Since then, *M. sabulicola* has been recorded in the Pacific Northwest from

British Columbia, Oregon, and Washington (Scudder 1960, 1961, Slater 1964).

Slater and Sweet (1958) first reported this immigrant lygaeid from eastern North America, listing it from three localities in Connecticut. Sweet (1964) gave Massachusetts (Cape Cod) as a new state record and additional Connecticut records. Inclusion of District of Columbia, New York, and Pennsylvania under the known eastern distribution of *M. sabulicola* (as *M. chiragra*) in the world lygaeid catalog (Slater 1964) was misleading. As Slater and Sweet (1958) discussed, these records represent quarantine interceptions at ports of entry rather than established populations. The only eastern records subsequent to Slater's (1964) catalog are ones likely to be overlooked: Ithaca, New York, cited without collection data (Pimentel and Wheeler 1973), and Talbot Co., Maryland, based on one female (Hoebeke 1977).

Because *M. sabulicola* had been intercepted at ports on produce originating in Czechoslovakia or France and because this species is less common in Great Britain than *M. chiragra*, Sweet (1964) suggested that continental Europe was the likely source of established eastern U. S. populations. Slater and Sweet (1958) postulated that *M. sabulicola* was introduced to the Northeast with imported plant material rather than with ships' ballast. A ballast origin of Pacific Northwest populations, however, is probable (Slater and Sweet 1958, Scudder 1961).

Herein, I give new distribution records of *M. sabulicola* in the eastern states and discuss its association with spotted knapweed, *Centaurea maculosa* Lam., a naturalized weedy composite of railroad right-of-ways and highway embankments. Characters allowing this immigrant heteropteran to be recognized in the Nearctic fauna are provided.

Distribution in Eastern North America

In addition to published records from Connecticut, Maryland, Massachusetts, and New York, the following records are available for *M. sabulicola* in the East (Fig. 1). Except as noted, all collections were made under *Centaurea maculosa* by the author (AGW); collection data are cited for Pimentel and Wheeler's (1973) New York record from Tompkins Co. Voucher specimens have been deposited in the insect collections of Cornell University (CUIC), Pennsylvania Department of Agriculture (PDA), and U. S. National Museum of Natural History (USNM).

Fig. 1. Known distribution of *Megalonotus sabulicola* in eastern North America. Open circles indicate previously published records; closed circles represent new records.

DELAWARE: *New Castle Co.*, Newark, 15 Oct. 1987, AGW and T. J. Henry. MARYLAND: *Harford Co.*, 195 S, Aberdeen Proving Grd. exit, 15 Oct. 1987, AGW and T. J. Henry; *Prince Georges Co.*, 195 S nr. Laurel, 15 Oct. 1987, AGW and T. J. Henry. NEW JERSEY: *Atlantic Co.*, Richland, 7 Oct. 1987; *Cumberland Co.*, Vineland, 26–28 May 1979, E. R. Hoebeke. NEW

YORK: *Chemung Co.*, Rt. 427 w. of Chemung, 19 Oct. 1987; *Tioga Co.*, Rt. 79. 1 mi. e. of Richford, 29 Oct. 1987; *Tompkins Co.*, Savage Farm, Ithaca, 3 July, 1 Aug. 1966, on alfalfa. PENNSYLVANIA: *Bedford Co.*, Rt. 220, s. of Cessna, 3 May 1988; *Berks Co.*, 3 mi. e. of Bethel, 8 Oct. 1987; Rt. 183 n. of Leinbachs and Rt. 198 s. of Bernville, 22 Oct. 1987; *Blair Co.*, Frankstown, 17 Nov. 1987; Tipton, 17 Apr. 1988; *Bradford Co.*, Canton, 16 Oct. 1987; *Cumberland Co.*, I81 N, 2 mi. s. of Rt. 114 nr. New Kingstown; *Dauphin Co.*, Early Mill Rd., 4.5 mi. n. of Hershey, 10 Aug. 1987, in house; *Franklin Co.*, Rt. 75 s. of Metal; PA Turnpike w. of Blue Mtn. tunnel and w. of Rt. 997, 9 Oct. 1987; *Fulton Co.*, Rt. 30 e. and Rt. 16 s.e. of McConnellsburg, 9 Oct. 1987; PA Turnpike, Sideling Hill Plaza, 3 May 1988; *Huntingdon Co.*, Huntingdon, 17 Nov. 1987; *Lackawanna* Co., Rt. 9 (NE Ext., PA Turnpike) nr. Scranton, 31 Mar. 1988; *Lancaster Co.*, I283 W at Rt. 772 nr. Mount Joy, 29 Sept. 1987; Elizabethtown, 3 Aug. 1988, on *Pinus mugo*; *Lebanon Co.*, I81 N, nr. Rt. 934, 28 Sept. 1987; Rt. 934 nr. junc. Rt. 22 nr. Harper Tavern, 28 Sept., 8 Oct. 1987 and 24 Mar., 17 & 24 May, 1 & 17 June 1988, AGW, J. E. Fetter, & J. F. Stimmel; *Luzerne Co.*, Hazleton, 29 Oct. 1987; *Lycoming Co.*, Trout Run, 16 Oct. 1987; *McKean Co.*, Bradford, 16 Aug. 1988; *Mifflin Co.*, 8 mi. e. of Mt. Union, 17 Nov. 1987; *Perry Co.*, Rt. 322 nr. Millerstown, 19 Apr. 1988; *Schuylkill Co.*, I81 N, .5 mi. s. & 1 mi. n. of Pine Grove exit and s. of Ravine, 8 Oct. 1987, AGW and J. F. Stimmel; *Union Co.*, Rt. 15, 1.2 mi. s. of Lewisburg, 16 Oct. 1987; *Wyoming Co.*, Tunkhannock, 29 Oct. 1987. RHODE ISLAND: *Kent Co.*, I95S, n. of Rt. 102 n.e. of Exeter, 3 Dec. 1987; VIRGINIA: *Augusta Co.*, Staunton, 7 Apr. 1988; *Roanoke Co.*, Rt. 220 n. of Boones Mill, 10 Apr. 1988; *Rockbridge Co.*, Rt. 11, 2 mi. s. of Fairfield, 10 Apr. 1988; *Shenandoah Co.*, Rt. 11, 1 mi. n. of Edinburg, 26 Nov. 1987 and Rt. 11 s. of Edinburg, 3 Dec. 1987; *Wythe Co.*, junc. I81S & I77S nr. Ft. Chiswell, 22 Apr. 1988, AGW & T. J. Henry. WEST VIRGINIA: *Berkeley Co.*, I81S nr. Falling Waters, 26 Nov. 1987.

Habitat and Host Preferences

Following the first Pennsylvania collection of *M. sabulicola*, a specimen taken in my house in Dauphin Co. on 10 August 1987, a survey was initiated to learn more about its distribution in the eastern states and to determine its host plant and habitat preferences. Slater and Sweet (1958) reported a close association of this lygaeid with cornflower or bachelor's-button, *Centaurea cyanus* L., in New England, and Sweet (1964) observed the bugs using their beaks to carry or drag fallen seeds to a sheltered site for feeding. This introduced species appears to compete poorly with native rhyparochromines and in New England is nearly always restricted to *C. cyanus* colonies growing in temporary habitats (Sweet 1964). Because the European *C. cyanus* is not extensively naturalized in Pennslyvania (Wherry et al. 1979), I began looking for *M. sabulicola* under spotted knapweed, *C. maculosa*, a common European weed that grows in ruderal situations similar to those in which Slater and Sweet (1958) encountered *C. cyanus* and associated populations of *M. sabulicola*, i.e. early-succession xeric sites.

Nymphs and adults were found initially by looking under *C. maculosa* plants colonizing shaly slopes along interstate highways (I81 in Lebanon Co. and I283 in Lancaster Co., Pennsylvania). To allow more sites to be surveyed, this rather time-consuming, scratch-and-search collecting method (Slater and Baranowski 1978: 9) was abandoned. Instead, a small shovel was used to scoop soil (about 0.25 ft^3) beneath spotted knapweed into a plastic bag. In the laboratory, specimens of *M. sabulicola* could be obtained by processing soil samples in a Berlese funnel, but its presence at a site could be determined more easily by sorting soil dumped into a white enamel tray. The bugs typically became concentrated in the bottom of the plastic bag and were collected

when the last batch of soil was placed in the tray.

Populations were readily detected by this method, and it was soon apparent that this immigrant rhyparochromine is common in eastern Pennslyvania. Fewer than five of the nearly 30 soil samples taken were negative for *M. sabulicola*. West of the Allegheny mountains, however, populations were more difficult to locate.

Megalonotus sabulicola was found consistently under *C. maculosa*. Soil nearly always could be taken beneath pure colonies owing to the plant's allelopathic effects on nearby vegetation (Fletcher and Renney 1963). Bugs were absent in the few soil samples taken under other composites, e.g. *Eupatorium* and *Solidago* spp. Nymphs and adults were found not only under spotted knapweed in sparse colonies on shaly highway embankments but under plants growing in other disturbed situations: in wet clayey soil, in vacant lots and at the edge of roads, in thick sod of pastures, in gravelly soil at the edge of parking lots, in gravel pits and stone quarries, and in fine sooty and sandy ballast along railroads.

As Slater and Sweet (1958) and Sweet (1964) noted, *M. sabulicola* is restricted to the litter layer near *Centaurea* plants. During the distribution survey, no adults were taken by sweeping spotted knapweed. Adults, probably dispersing individuals, sometimes occur on other vegetation; for example, they have been collected on strawberries (Scudder 1961) and corn (Hoebeke 1977). On two occasions at Ithaca, New York, adults were collected on alfalfa, *Medicago sativa* L.; at Elizabethtown, Pennsylvania, an adult was beaten from a small Swiss mountain pine, *Pinus mugo* Turra.

During 1987–88, a population of *M. sabulicola* associated with spotted knapweed growing at the edge of a gravel parking lot along Rt. 934 near its junction with Rt. 22 (Lebanon Co., Pa.) was monitored more frequently than other sites but only at irregular intervals. Based on a composite of observations made in Pennsylvania and other mid-Atlantic states, phenology conforms generally with that reported for bivoltine populations of the bug in New England (Sweet 1964).

This lygaeid overwinters in the adult stage. Overwintering individuals were found in litter and soil taken beneath spotted knapweed from mid-October to early December and during late March to early May. In Pennsylvania, first and second instars occurred in early June, with first generation adults appearing by early July. Early instars of a second generation were not collected, but fourth and fifth instars were found during mid-August. They were present until late September and were found in southern New Jersey with a few second and third instars in early October.

At Canaan in Connecticut's northern highlands, Sweet (1964) found that overwintered adults oviposited from May to early June, the tacklike eggs attached to litter beneath hosts, sand, or plant fuzz. In early June, Connecticut populations consisted mainly of first and second instars; by late June, a few fifth instars were present with larger numbers of instars II–IV. First generation adults appeared during July, and first instars of a second generation were observed in late July. The two generations overlapped considerably; some first generation females continued to oviposit into August. Second generation adults entered a reproductive diapause. By late September, Sweet found that the Canaan population consisted of 80% adults, 19% fifth instars, and 1% fourth instars. By mid-October, adults made up 95% of the population. Compared to Canaan, phenology at Storrs in eastern Connecticut was advanced by about three weeks (Sweet 1964).

Effects on Spotted Knapweed Populations

Centaurea maculosa is a biennial or short-lived perennial (Watson and Renney 1974, Maddox 1979) belonging to the composite subfamily Cynaroideae, which includes the well-known thistle genera *Carduus* and *Cir-*

sium. In some recent schemes of higher classification, *Centaurea* is placed in the tribe Cardueae, subtribe Centaureinae (Dittrich 1977, Zwölfer 1988). Spotted knapweed is thought to have been introduced to North America in alfalfa seed that originated in continental Europe or Asia Minor-Turkmenistan (Maddox 1979). Although this invasive plant is a pioneer species useful in erosion control, it poses a serious threat to western rangelands, where millions of acres are infested (Maddox 1979). It also is pestiferous in rangelands of British Columbia (Strang et al. 1979) and is listed as a noxious weed in Manitoba (Watson and Renney 1974). Well established in Ontario, Quebec, and the Canadian maritime provinces (Watson and Renney 1974), spotted knapweed generally infests the eastern United States except for the Deep South (USDA 1971).

Since 1970, several seed-and root-feeding insects have been evaluated and released for their biocontrol potential against spotted knapweed (Harris and Myers 1981, Müller et al. 1988). *Megalonotus sabulicola*, an inadvertent introduction, should be included among the seed-destroying insects associated with *C. maculosa*. Sweet (1960, 1964) discussed the ecological role of seed bugs belonging to the large lygaeid subfamily Rhyparochrominae. Seed destruction not only results from the piercing of seed coats but, according to Sweet (1964), probably from subsequent invasion by pathogenic fungi. Eyles (1964) also discussed seed-feeding behavior of rhyparochromines, including destruction of the embryo.

Habits of *M. sabulicola* have not been studied in western North America, but the identification of *Centaurea cyanus* seeds as a preferred food source in New England (Slater and Sweet 1958, Sweet 1964) gave more meaning to the seemingly accidental occurrence of the lygaeid in Oregon pea fields. In reporting three specimens from the Willamette Valley, Larson and Hinman (1932) remarked that the crop was infested by weeds, mainly cornflower, *C. cyanus*, and Canada thistle, *Cirsium arvense* (L.) Scop. The lygaeid probably was feeding on *C. cyanus* seeds in the litter layer of pea fields in Oregon and may now be established in areas of western rangeland infested with *C. maculosa*.

In the East, *M. sabulicola*, as a seed feeder closely associated with spotted knapweed, should be considered beneficial. Prolific seed production, however, is characteristic of *C. maculosa*, with as many as 40,000 seeds/m^2 capable of being produced (Watson and Renney 1974). Some of the insects released in biocontrol efforts against *Centaurea* spp. significantly curtail seed production but have failed to limit plant density (Harris and Myers 1981, Müller et al. 1988). *Megalonotus sabulicola* may also destroy large numbers of seeds, but its effects on plant reproduction must be minimal. Even in areas of Pennsylvania where this accidentally introduced seed predator has become abundant, stands of spotted knapweed continue to flourish.

Recognition Features

Megalonotus sabulicola (Fig. 2) may be placed in the large subfamily Rhyparochrominae by having the suture between abdominal sterna 4 and 5 curving anteriorly, not meeting the lateral margin. Adults are hairy, medium-sized, usually macropterous lygaeids with hemelytra a mottled brown-testaceous, somewhat contrasting with the dull piceous head, pronotum, and scutellum. Adults can be additionally characterized as 3.80–5.40 mm long (New York and Pennsylvania specimens), somewhat elongate, broadest across posterior third of hemelytra; head relatively short, declivent, rostrum extending to bases of mesocoxae; pronotum trapeziform, punctate, separated into anterior and raised posterior lobes, anterior margin lacking ringlike collar, lateral margin distinctly carinate; scutellum punctate, longer than wide; long, erect, bristlelike setae on head, pronotum, and scutellum

Fig. 2. *Megalonotus sabulicola*, adult habitus; scale bar = 1.0 mm.

(those on head and scutellum about 0.25 mm long) intermixed with finer, paler, more appressed setae; forefemur black, incrassate with prominent tooth ventrally on apical third; meso- and metafemora black apically, yellowish basally; tibiae yellowish, with stout dark spines.

The antennal and tibial characters Southwood (1963) used to separate *M. sabulicola* from *M. chiragra*—antennal segment II and hind tibiae in *sabulicola* almost wholly yellow and antennal segment III with broad, central, yellow band—do not always hold true for eastern U.S. specimens. Sweet (1964) noted that in certain New England populations antennae and hind tibiae showed the dark *chiragra*-like color patterns. Specimens (ca. 120) collected in this study, however, always have antennal segment II and the hind tibiae yellow or pale yellowish brown, whereas antennal segment III varies from mostly yellow to entirely black.

Fifth-instar nymphs can be keyed in Sweet and Slater (1961); nymphal characters distinguishing members of the tribe Megalonotini are discussed by Slater and Sweet (1961). Slater and Sweet (1958) described instars III–V.

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